3.0 FIELD TESTS

This section describes the field tests undertaken to test the use of videotape in HOV lane surveillance and enforcement. Each test is described, findings from the field demonstrations and subsequent analyses are documented, and results are summarized.

3.1 INITIAL CAMERA TEST

The initial test of the use of video equipment in HOV lane surveillance took place on the Winnetka Road overcrossing overlooking the Simi Valley Freeway on August 22, 1989. The test was designed to explore alternative lens settings, camera positions, and monitor displays. Although there is no HOV lane on the Simi Valley Freeway, the Winnetka Road overpass is unused and provided a good setting for experimenting with a variety of camera positions trained on vehicles in the number-one lane.

3.1.1 Test Equipment

A mobile video van was employed in the tests. This unit included four high-speed video cameras operated from a control console having a split screen capability. An infra-red camera and light source were also available. Two 3/4" video recording units were used in conjunction with two monitors to provide simultaneous playback and recording capability. A motor-generator supplied AC power for all of the equipment. The relative positions of the four cameras and the control van are diagrammed in Exhibit 3.1.

3.1.2 Test Sequence

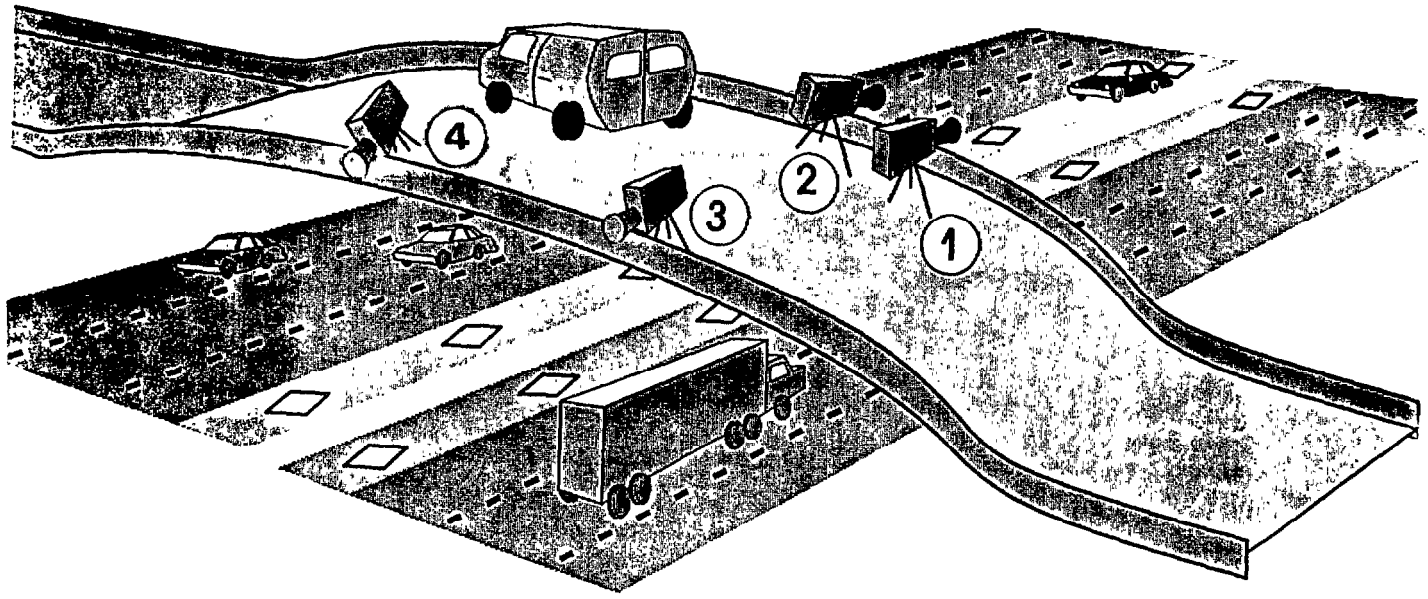
infra-Red Test. The ATD crew began setting up equipment at approximately 4:00 a.m. in order to test the feasibility of obtaining videotape records under conditions of darkness and poor visibility. An infra-red camera and light source were used during this phase of the test.

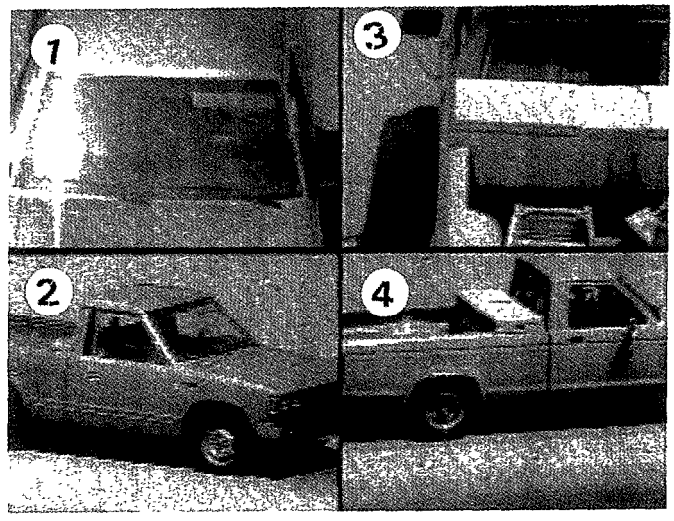
Three-Camera Test. When daylight permitted, four cameras were set up to record occupancy and license plate information simultaneously (see Exhibit 3.1). Three cameras were initially deployed as follows:

EXHIBIT 3.1

INITIAL SET-UP

1. Oncoming View
2. Oblique Oncoming View
3. License View
4. Oblique Departing View





Camera 1: One high-speed video camera was positioned on the overpass facing oncoming traffic to provide an oncoming view of vehicles traveling in the number 1 lane and their license plates.

Camera 2: A second high-speed camera was placed on the same side of the overpass to provide an oblique view of vehicles in the number one lane. The angle of this camera was varied from 90° (right angles to the freeway) to 45° in order to determine the most advantageous position.

Camera 3: A third high-speed camera was placed on the opposite side of the overpass facing the rear of the vehicles traveling in the number one lane. This camera provided a view of the rear window of the car as well as license plate data.

Information from all three cameras was displayed simultaneously in a split-screen format on a single monitor. Sample split-screen displays appear in Exhibit 3.2. In addition, a separate monitor recorded the license plate images provided by Camera 3. Camera positions were adjusted to determine the most advantageous positioning, and a variety of split-screen presentations were tested to determine the configurations best suited for observing vehicle occupancy.

Four-Camera Test. A fourth camera was ultimately added to the three-camera configuration described above in order to provide an oblique view of the rear of vehicles after they had passed by the observation post. Views from all four cameras were displayed in four quadrants of a split screen monitor, and the position of the fourth camera was adjusted to provide the most advantageous position.

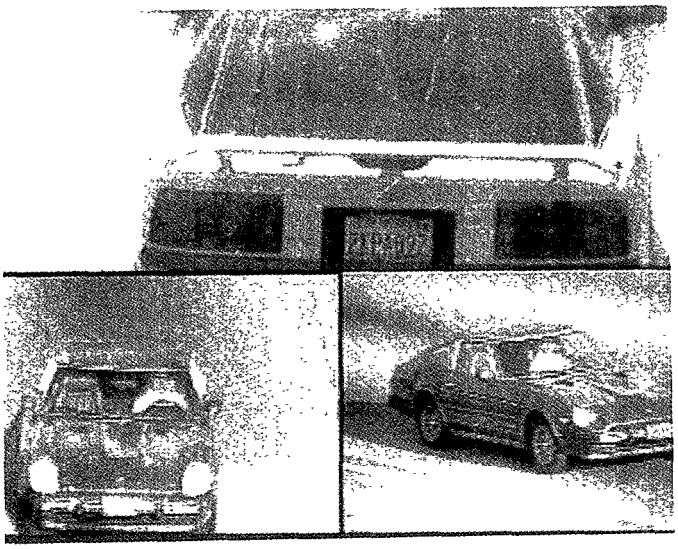
3.1.3 Post-Test Analysis

Sample Videotape. A sample videotape was prepared from the footage recorded at the Winnetka Road overcrossing to facilitate the evaluation of different camera angles and monitor displays. The sample tape included fourteen different TV monitor displays involving a combination of camera angles. The fourteen displays were characterized as follows:

1. Single camera, rear view
2. Single camera, front view
3. Single camera, rear view
4. Single camera, side view (R to L)
5. Single camera, side view (L to R)
6. Single camera, rear angle
7. Three cameras, rear view vesticle (Display B in Exhibit 3.2)
8. Three cameras, rear view horizontal (Display A in Attachment B)
9. Four cameras, black and white front view
10. Four camera (Display C in Attachment B)
11. Single camera, front view
12. Single camera, side view
13. Single camera, rear view (dark)
14. Four cameras, synchronized view

EXHIBIT 3.2

SAMPLE VIDEO MONITOR OUTPUT

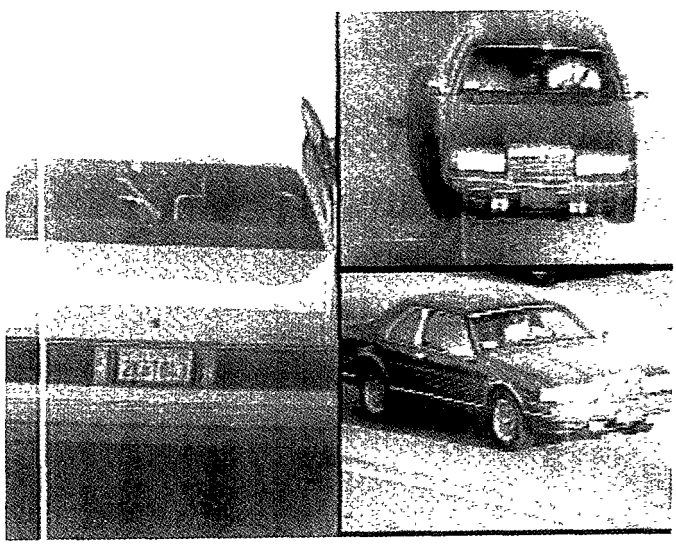


(A) THREE-CAMERA DISPLAY

1. Rear View of Departing Vehicle
2. Front View of Oncoming Vehicle
3. Oblique View of Oncoming Vehicle

(B) THREE-CAMERA DISPLAY

1. Rear View of Departing Vehicle
2. Front View of Oncoming Vehicle
3. Oblique View of Oncoming Vehicle



(C) FOUR-CAMERA DISPLAY

1. Front View of Oncoming Vehicle
2. Oblique View of Oncoming Vehicle
3. Rear View of Departing Vehicle
4. Side View of Departing Vehicle

Procedure. To test viewer reactions to the sample videotape, a standard form was prepared that identified vehicles by description (license numbers where available, size and color otherwise) and tape location. Five raters were asked to view the tape and assess the occupancy of each vehicle and determine whether the driver was wearing a seat belt. Occupancy choices were 1, 2, 2+, 3, 3+ and "unknown." Seat belt use was identified as "yes," "no," or "?".

A maximum of 25 cars were rated in each of the fourteen sample displays. In all, a total of 232 cars were identified specifically on the rating sheet. All but one rater was able to locate all of the vehicles identified on the sheet. All of the raters reported that they had no particular difficulty with the process.

Raters were provided with stop-motion and rewind controls and allowed to take as much time as they wished in identifying vehicles. They were instructed to make sure that they reviewed all views of a vehicle in the multiple camera displays before completing the rating. The amount of time raters took to review and record their responses to 232 vehicles ranged from one hour and thirty minutes to three hours and fifteen minutes.

Appendix A summarizes the five rater evaluations for each of the fourteenn displays. A review of this information and observation of the rating process suggests that:

- Vehicle ocupancy was easier to observe than seatbelt use;
- No single display produced unanimity of results among raters;
- Single-occupant vehicles were easiest to identify;
- In considering the multi-camera displays, raters tended to prefer three-camera displays to four-camera displays, since they felt the views provided in the four-way split were too small;
- The various displays produced wide variations in rater consistency. Raters provided the most consistent responses to the three-camera and four-camera displays (#8 and #9). The least consistent responses were obtained in rear-view shots (#I and #3), right-angle shots (#12), and the synchronized four-way shot (#14).

Raters were asked to comment on the advantages and disadvantages of each alternative, but few had specific comments. By the time they had finished their task, the individual displays had run together in their minds.

3.1.4 Preliminary Findings

The field tests and subsequent tape review led to the following tentative conclusions.

1. **After-Dark Videotaping.** Although it is possible to videotape license plates from the rear using an infra-red camera and light sources, it does not appear feasible to document occupancy under conditions of darkness or low visibility. Results are not clear and the light source can be a distraction to oncoming drivers.

2. **Playback Necessity.** Under real-time viewing conditions, it is usually necessary to play back the videotape to make sure that a vehicle suspected of violating HOV requirements actually has too few occupants. The playback/conformation action can take from 30 seconds to one minute, so that any officers responding to broadcast descriptions of violators will have to be at least one to two miles downstream from the taping site.

3. **Number of Cameras.** During the field test, the four-camera set-up appeared to provide the most useful information on vehicle occupancy. However, viewers reviewing the tape after the fact preferred the three-camera setup, feeling that the images provided in the four-way split were too small.

4. **Camera Angles.** During the initial trial, it appeared that the camera facing the oncoming vehicles (Camera 1 in Exhibit 3.1) should be set at a shallow angle (with the horizon) to keep vehicles in the frame as long as possible. The oblique camera (Camera 2) should be aimed to cover the same field of vision as the camera facing traffic directly. In this way, the two views of the vehicle (head on and oblique) appear simultaneously on the split screen, providing a visual cue to the monitor viewer. As a practical matter, the amount of occupancy information provided by the oblique camera appeared to increase as the angle between the camera and the roadway decreased (i.e. as the camera was aimed farther down the roadway). Very little useful information was transmitted when the camera was set at right angles to the roadway.

   The two cameras trained on the rear of departing cars should be focused at sharper angles to the freeway to provide clearer license plate definition. As with the forward-facing camera, the oblique camera (Camera 4 in Exhibit 3.1) should be trained on the same segment of freeway as the camera directly over the departing cars (Camera 3).

5. **Missed Observations.** Although the four-camera system provided conclusive occupancy information on most vehicles, car design, camera angles, glare, tinted windshields, changing light conditions and a variety of other problems made it impossible to obtain occupancy information on 100% of the vehicles videotaped.

6. **Simultaneous Display.** Although it is possible to acquire video equipment capable of introducing an on-line time delay in the monitoring system so that all four images of a single vehicle are displayed simultaneously, the expense of this equipment (currently estimated at roughly $50,000) does not appear to be justified. Furthermore, the on-line delay would have to be adjusted constantly as vehicle speeds change. The on-site observer will have to review the tape under most circumstances, and can quickly review the separate images produced by the two forward-facing cameras and the two rear-facing cameras. Any requirement for simultaneous hard-copy records can be manufactured in the studio after the initial data have been recorded.

7. **License Plate Documentation.** License plates can be captured with sufficient accuracy on the quarter-screen display of the multiple-image monitor. They need not have a separate dedicated full-screen monitor.

3.2 INITIAL ENFORCEMENT TEST

On October 19, the first of a series of tests using CHP officers and on-line video displays to identify possible violators was undertaken. The test took place at the Wilmington Avenue overpass overlooking the eastbound HOV lane on LA 91. As the demonstration was initially set up, a single officer in the control van monitored the video display and radioed descriptions of suspected violators ahead to two motor officers. The two motor officers verified the number of occupants in the vehicle and, at their discretion, issued citations to drivers violating the HOV lane's occupancy requirements.

3.2.1 Demonstration Set Up

Equipment. Three cameras were set up on the Wilmington Avenue overcrossing and linked to two video monitors in the observation van. The location of the camera is diagrammed in Exhibit 3.3. Two cameras focused on oncoming traffic in the HOV lane, while the third camera recorded license plates of departing vehicles. One of the monitors in the van provided an on-going, time indexed record of the three camera views. Exhibit 3.4 shows the three views displayed on the monitor. The second monitor provided the viewing officer with a stop-action and review capability which made it possible to replay and reexamine the images of suspected violators before making a final decision on the number of occupants.

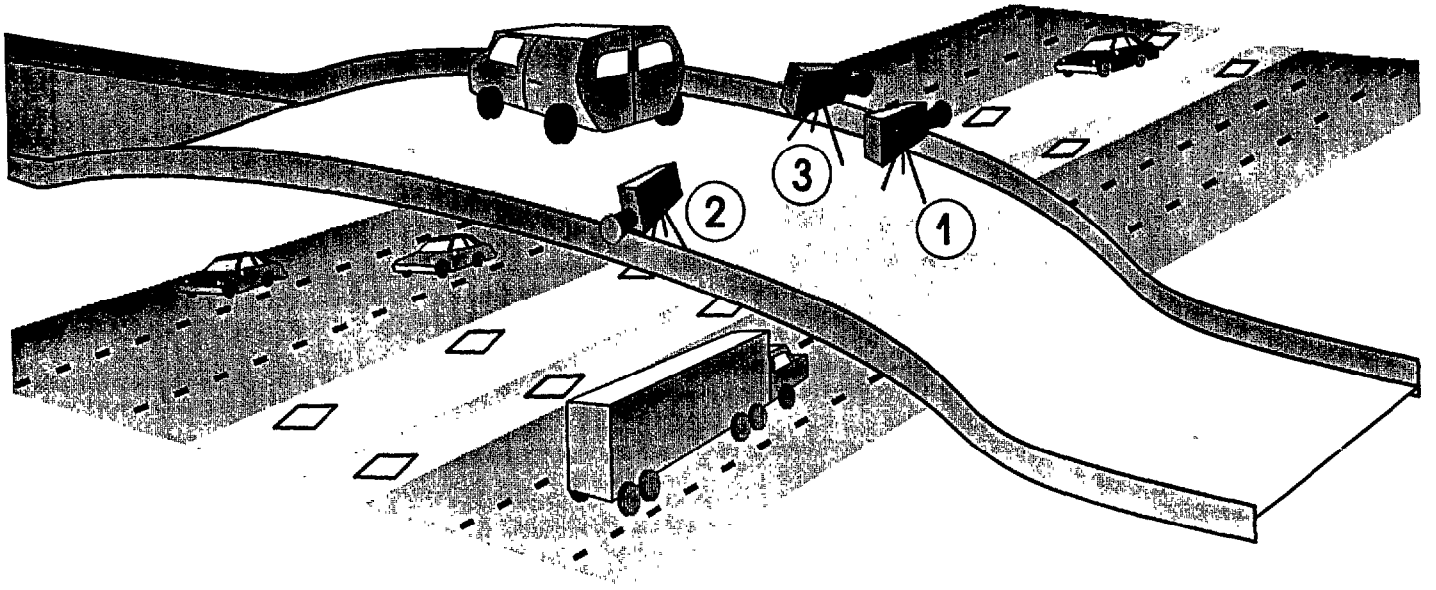
Officer Participation. The video equipment was in place and running by 12:00 noon. At that time two motor officers took up positions at onramps roughly one-and-a-half miles downstream from Wilmington Avenue. A third officer was stationed in the observation van and given a brief run-down on equipment operations. The three officers then experimented with the tool during the relatively light midday traffic. When the observing officer spotted a potential violator, she would review the tape, note the license number, and radio the vehicle description ahead to the two motor officers, who would pursue the suspect and verify the violation. Even during the light midday traffic, some suspected violators went unverified if the motor officers were busy pursuing previous calls.

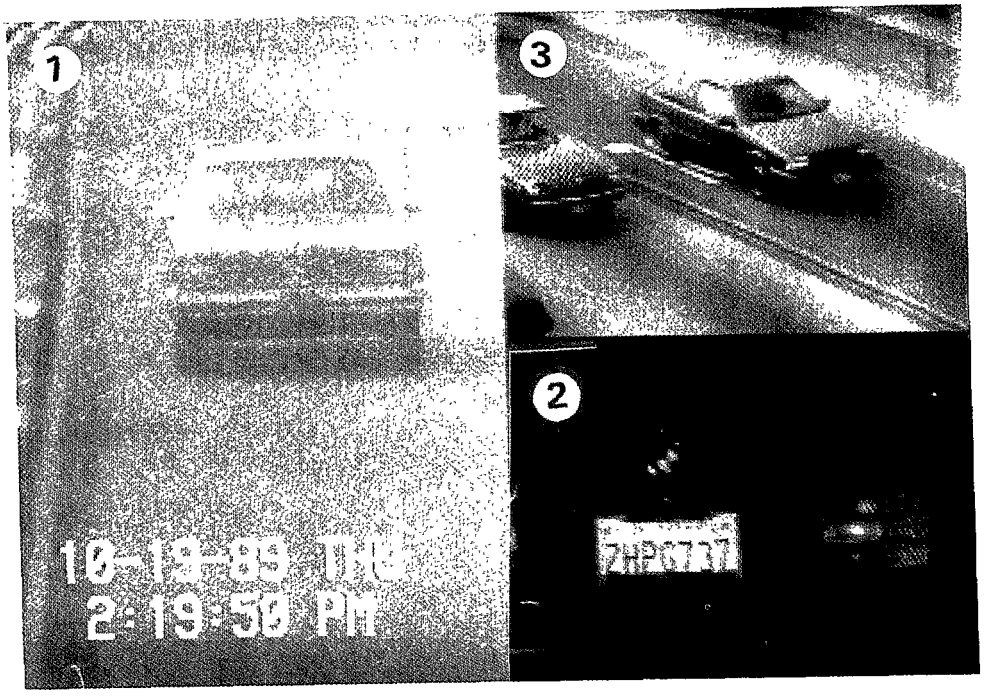
EXHIBIT 3.3

INITIAL ENFORCEMENT SET-UP

Three Cameras On Bridge

1. **Oncoming View**
2. **License View**
3. **Oblique View**





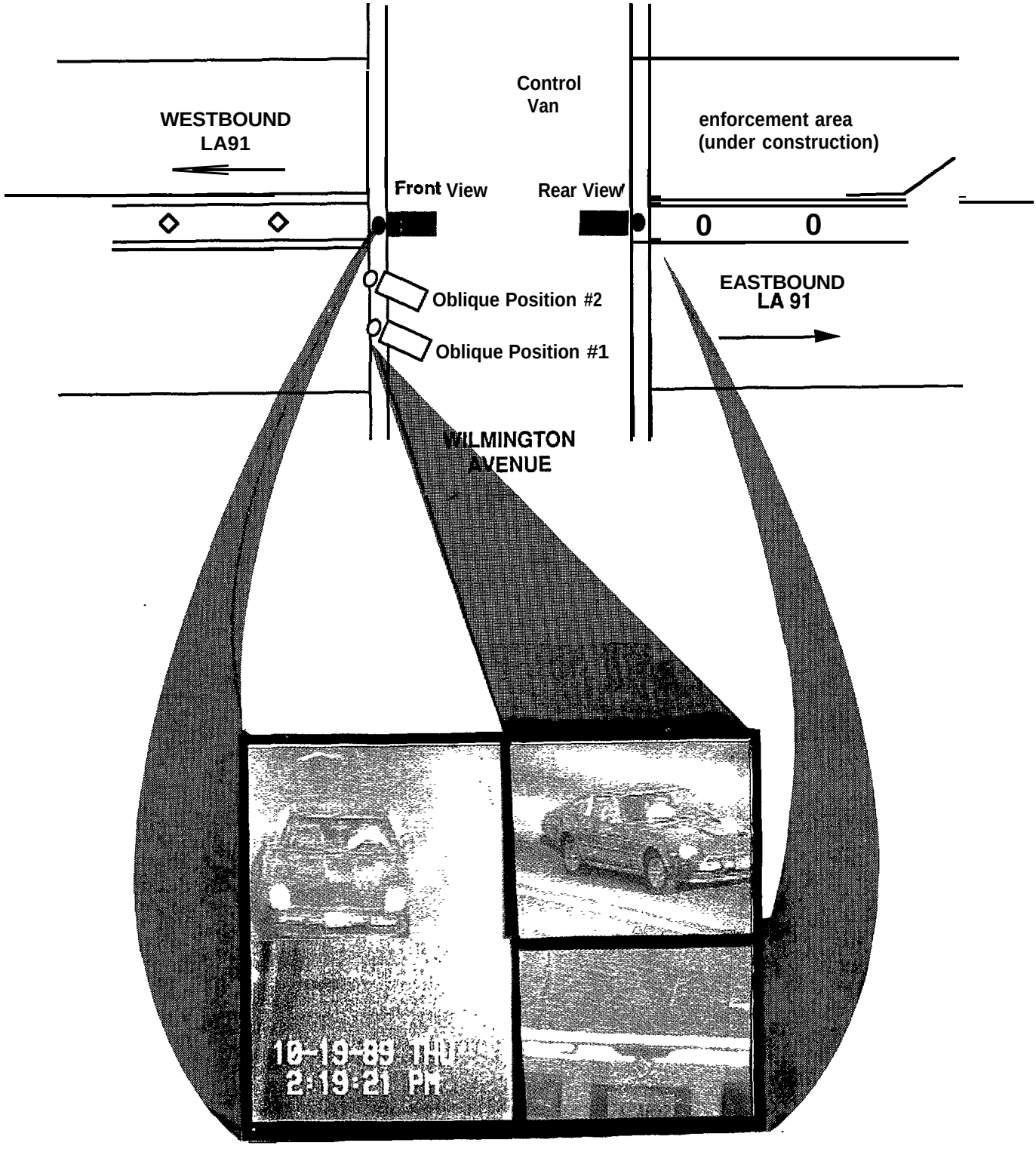


EXHIBIT 3.4

MONITOR DISPLAY
INITIAL ENFORCEMENT TESTS

At 2:00 p.m. the CHP shifts changed, and a new set of officers replaced the initial participants. The incoming officer quickly learned videotape operations, and the new team of officers was in place by 2:19.

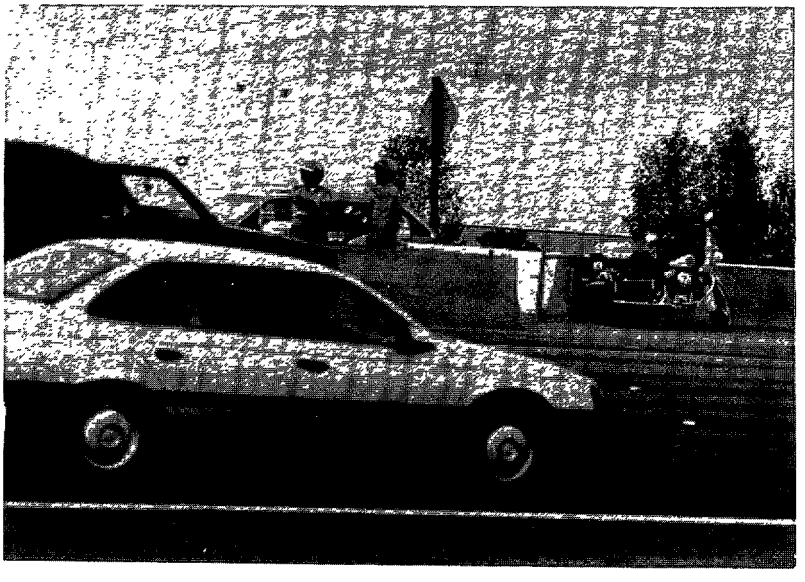
As the evening commuter traffic built up, it became increasingly difficult for motor officers to pursue violators from positions near freeway ramps. When it became apparent that more and more suspects were escaping unverified, the officers repositioned themselves at an enforcement area being constructed about 1500 feet downstream from the observation point. (See Exhibit 3.5.) From this stationary position next to the HOV lane, they were able to observe most of the suspected violators identified by the officer viewing the videotape.

3.2.2 Analysis of Results

Field Test Findings. A summary of the traffic observations made by the second team of officers during the evening commute period appears below:

TIME	SUSPECTED VIOLATORS OBSERVED	VIOLATOR DESCRIPTIONS SENT	VIOLATOR DESCRIPTION ACKNOWLEDGED	VERIFICATION RESULTS		
				VIOLATOR VERIFIED	SUSPECT NOT A VIOLATOR	UNABLE TO OBSERVE SUSPECT
INITIAL TIME 2:15-3:25 (Motor officers pursuing)	12	12	11	1	5	5
OFFICERS REPOSITIONED 3:30-4:20 (Motor officers stationary in enforcement area)	29	29	28	18	10	0
CAMERA REPOSITIONED 4:29-5:00 (Motor officers stationary)	18	18	16	8	6	2
TOTAL	59	59	55	27	21	7

VAN AND REAR-VIEW CAMERA



OFFICERS IN ENFORCEMENT AREA

EXHIBIT 3.5

VIDEOTAPE DEMONSTRATION PHOTOS

Motor officers were able to observe 48 of the 59 (81%) suspected violators whose descriptions were broadcast by the observing officers. Of the suspects actually observed, 27 of 48 (56%) were verified as violators. However visual observation at freeway level showed that 44% of the suspects turned out to have the required number of occupants. This rate of false alarms is far too high for any mail-out warning scheme. However, the rate represented the results of a first trial, and several adjustments were identified to improve future accuracy.

Both of the officers assigned to the van were able to master the use of the video monitor quickly and with no difficulty. At first, both tended to try to review the tape on potential violators before the violator had passed by the third (rear-view) camera, but this tendency was quickly remedied.

The position of the oblique camera was adjusted at 4:30 p.m. to provide a more direct view downward view into the passenger seat of the oncoming vehicles. The observing officer felt that this view "...improved things 110%" but it did not noticeably reduce the false alarm rate.

Data Reduction. In order to check the relative accuracy of the officers making decisions during peak commuting hours against the accuracy of office workers reviewing the videotape under more relaxed conditions, office personnel subsequently screened the October 19 tape record for the hour between 3:30 p.m. and 4:30 p.m., classifying vehicle occupancies. The occupancy records documented by reviewers during that period are listed below.

LA 91: 10/19/89 Vehicle Occupancy 3:30 p.m. to 4:30 p.m.	1	2	3	3+	Can't Tell	Total
Number	86	947	111	45	58	1247
Percent	6.9%	75.9%	8.9%	3.6%	4.7%	100%

Thus the office reviewers counted 86 violators during the one-hour period, a violation rate of 6.9%. Over the same period, the CHP officer viewing the videotape on the scene had identified 29 potential violators. When field officers assigned to the freeway checked these 29 vehicles, they found that 19 actually were violators, while 10 had at least two occupants. This represented a success rate of 66%.

Only fourteen of the twenty-nine vehicles verified by officers at the time of the field trial were identified as potential violators by the office reviewers. Of these, eleven vehicles had been identified as actual violators, while three had the required number of occupants, even though they escaped the camera's eyes. This represented a success rate of 79% for the office reviewers.

As would be expected, reviewers identified more potential violators than the officer on the scene, who needed to make decisions in real time and was often reviewing videotape or conferring with field officers as other violators passed before the camera. It is also not too surprising that the office reviewers, who enjoyed the luxury of unlimited screening time, had a higher percentage of accuracy (79% vs. 66%) than the field officer. Because of the relatively small sample size this higher accuracy percentage is not statistically significant (at the 5% significance level).

3.2.3 Preliminary Findings

The following preliminary conclusions and observations were made following the initial videotape/enforcement demonstration on LA 91. These observations and findings would be tested further in subsequent demonstration runs.

1. **Real-Time Enforcement Efficacy.** The use of videotape as a real-time enforcement aid appeared to be somewhat limited. The officer in the van radioed descriptions of more potential violators than the two motor officers could apprehend, but he could easily have made the same observations from a roadside enforcement area, where his presence might have had a cautionary effect on drivers. The only locations where an officer in the videotape van might be better able to assist on-line enforcement than an officer on the freeway would be those locations where there is no refuge area adjacent to the HOV lane. If there is no median shoulder or enforcement area where an officer can be situated for enforcement purposes, video-assisted enforcement stops might make more sense. The Marin 101 HOV lane is a good example of such a location. In the previous test of enforcement tactics on Marin 101, it was virtually impossible to find an adjacent location where a motor officer could safely observe traffic (Billheimer, 1990).

2. **Camera Positioning.** The ability of officers stationed beside the HOV lane to sight violators that escaped detection by the overcrossing camera suggested that an unobtrusive freeway-level micro-camera might be used to good advantage in HOV lane surveillance.

3. **Technical Difficulties.** A few technical problems were noted which would be corrected in future runs.

   - At certain times of day, windshield glare prevented viewers from observing the number of vehicle occupants. On future runs, polarized filters would be used to combat this effect.

- Different lengths of cable leads from the control van made it difficult to synchronize the color and images provided by the three cameras. On future runs, cable leads would be reconfigured to balance line resistance and minimize this problem.

3.3 EYE-LEVEL CAMERA TESTS

Since officers in the enforcement area alongside the HOV lane on LA 91 were able to detect occupancy violations with more success than cameras and observers stationed on overpasses above the HOV lane, ATD undertook the development of a camera that could record the same view as that seen by the roadside officers. Since this camera would be located alongside the HOV lane, it was essential that it be unobtrusive enough to avoid distracting passing drivers. To that end, they developed a micro-camera and mount capable of being installed on the median divider.

3.3.1 Field Testing

Three field tests were made to develop, test, and demonstrate the roadside micro-camera.

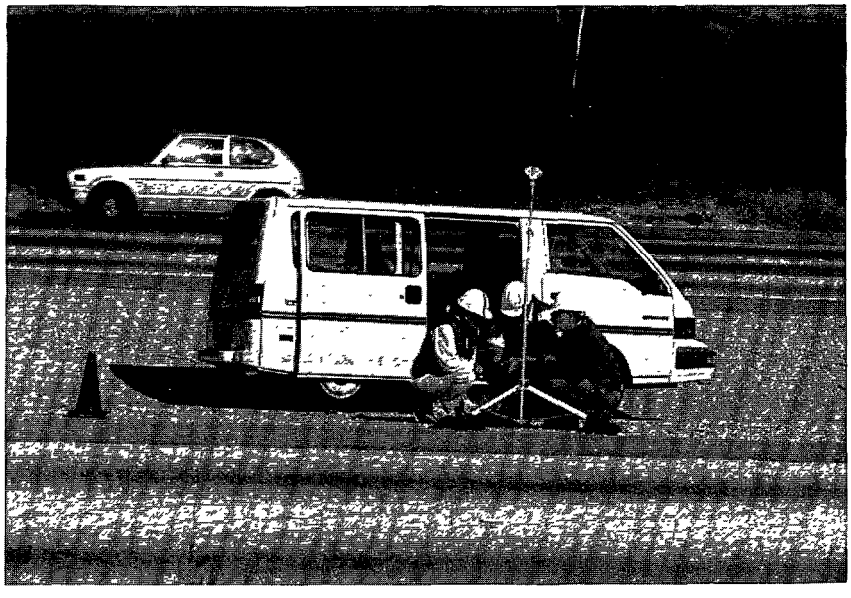
(1) On December 12, 1989, ATD tested the installation of a micro-camera along the Simi Valley freeway at the Winnetka overcrossing. Various camera levels were tested, and best results were obtained from a camera position slightly higher than the car roof, angled downward to provide a view of the passenger seat and right rear seat. Exhibit 3.6-A shows the camera-tripod arrangement tested on the Simi Valley Freeway.

(2) On December 14, 1989, ATD tested the use of polarized filters in conjunction with the micro-camera. The test was conducted on DeSoto Avenue near ATD headquarters, and resulted in the development of a tiny filter capable of reducing the effect of glare when the micro-camera is recording.

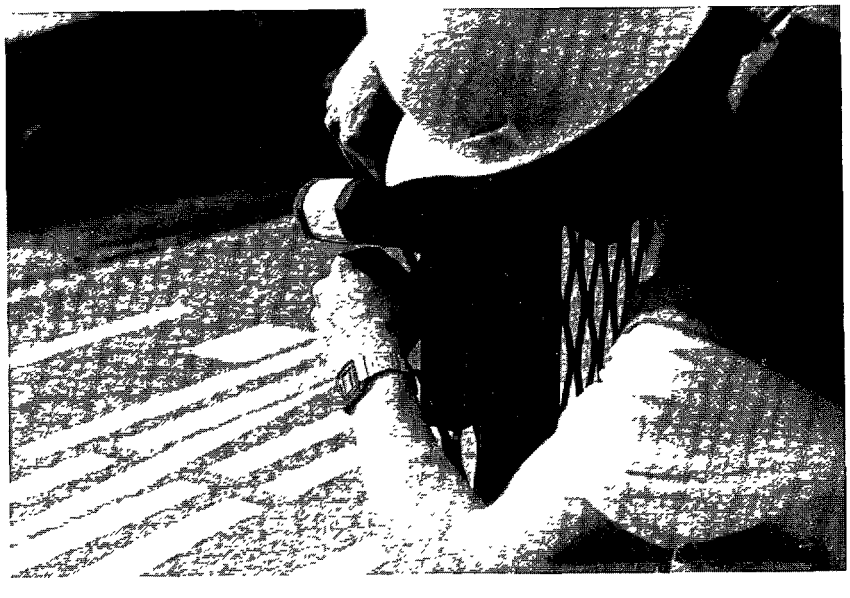
(3) On December 19, 1989, the team tested the eye-level micro-camera on LA 91 with CHP officers present to review the videotape and verify violations on the freeway itself. Exhibit 3.6-B shows the micro-camera installation on a fence post rising from the LA 91 center divider, while Exhibit 3.7 shows the relative positions of the three cameras used in the demonstration. Two experienced CALTRANS freeway observers were also on hand to count vehicle occupants from the bridge level and provide a basis for comparing manual and videotape counts.

EXHIBIT 3.6

TESTS OF EYE-LEVEL MICRO-CAMERA



B-1 Testing Eye-Level Microcamera on Simi Valley Freeway

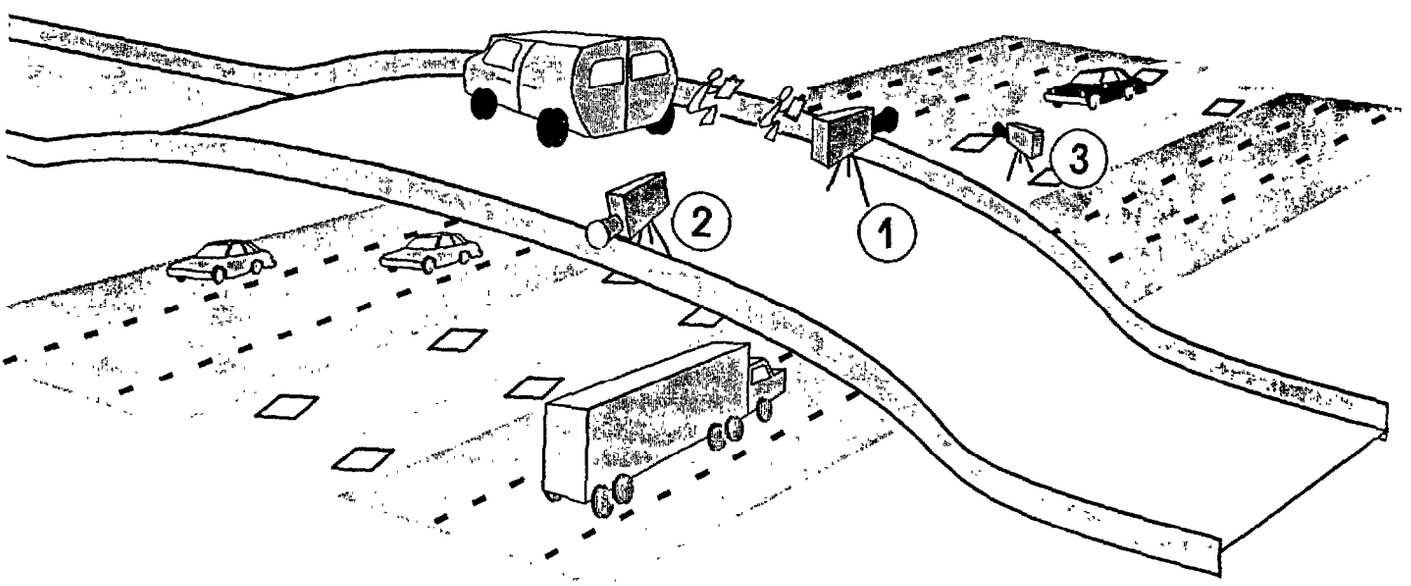


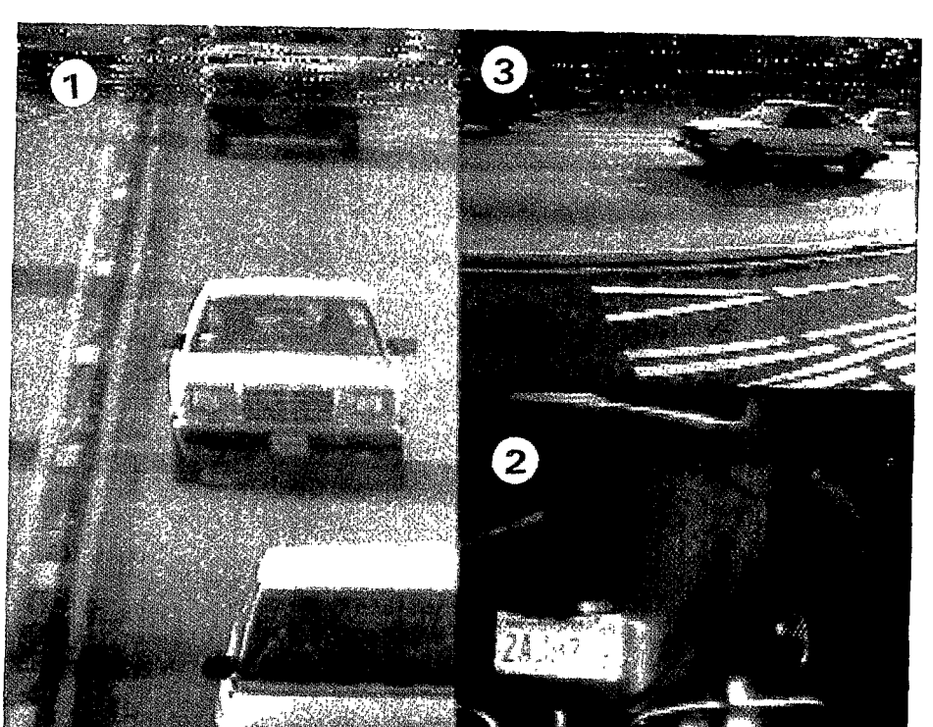
B-2 Installing Eye-Level Microcamera on LA Route 91

EXHIBIT 3.7

Two Bridge Cameras And Eye-Level Camera

1. Oncoming View
2. License View
3. Drivers Eye Level View





3.3.2 Test Results

Camera Functioning. The primary purpose of the series of tests undertaken in December 1989 was to develop and demonstrate a micro-camera suitable for roadside installation. From this technological standpoint, the tests were successful. The micro-camera was small enough to avoid distracting drivers and still provide useful information to the control van monitor. Exhibit 3.8 shows one of the views provided by the eye-level micro-camera. The camera provided a good view of rear-seat occupants, particularly those in the right rear passenger seat. Occupants in the left rear seat whose heads were below window level might still escape detection. Depending on car design and shutter-timing, riders in the passenger seat next to the driver could be obscured by the windshield post.

Enforcement Support. Attempts to document the accuracy of the three-camera set up on LA 91 on December 19 were marred by several problems.

1. Shortly after the cameras were in place, a truck overturned at the freeway ramp linking eastbound LA 91 to southbound LA 710. This accident occurred downstream from the test overpass, and the participating officers were called away to deal with the emergency.
2. When the officers returned, they experienced problems establishing a communications frequency separate from the Westminster area's dispatch frequency.
3. The license plate camera failed intermittently, as did a replacement camera.
4. The control van monitor was not fitted with a timer unit, making it difficult to document ongoing activities for future reference.

All officers had returned and established a working communication channel by 4:00 p.m., and were able to verify suspect violations for a half-hour, before it became too dark to proceed. Unfortunately, the intermittent failure of the license plate camera made it difficult to undertake a subsequent analysis of the tape to compare reviewer observations with on-line verifications.

3.3.3 Observations

On-Line Accuracy. The officer viewing the monitor in the van tended to rely on a single camera view, the view of oncoming traffic provided by Camera #1, in determining whether or not a vehicle was a violator. He rarely experimented with the monitor controls to get the

EXHIBIT 3.8

SAMPLE VIEW FROM EYE-LEVEL CAMERA

benefits of the eye-level camera. This may have been because the motor officers observing traffic were located in an enforcement area only 1500 feet downstream from the overcrossing, so that decisions had to be made rapidly. During the period between 4:00 p.m. and 4:30, the officer in the control van radioed the descriptions of 24 suspected violators to the motor officers downstream. Eight of these 24 suspects were found to have the required number of passengers, eight were identified as violators, and eight were not located.* Of the sixteen suspects verified by close-up observation, therefore, only 50% turned out to be actual violators. This high false-alarm rate can't be taken as a comment on the accuracy of the eye-level camera, however, since in most cases the van officer did not wait to consult the eye-level camera before radioing suspect descriptions.

Counter Accuracy During the same 4:00 to 4:30 period that the van officer identified 24 suspect violators, CALTRANS observers positioned on the overpass counted 32 violations. While CALTRANS counters observed every vehicle, the van officer sometimes took time to rewind the tape and take a second look at a suspect vehicle. Hence it is not surprising that the observers would count more violators than the van officer. However, the fact that only half of the suspects identified by the van officer turned out to be violators suggested that the observers may also be overstating the actual number of violators. This possibility would be further tested in the final videotape demonstration.

3.4 FINAL ENFORCEMENT TEST

The final test of videotape technology in enforcement took place on January 4, 1990 at the Warner Avenue overcrossing on OR 55.

3.4.1 Demonstration Set-Up

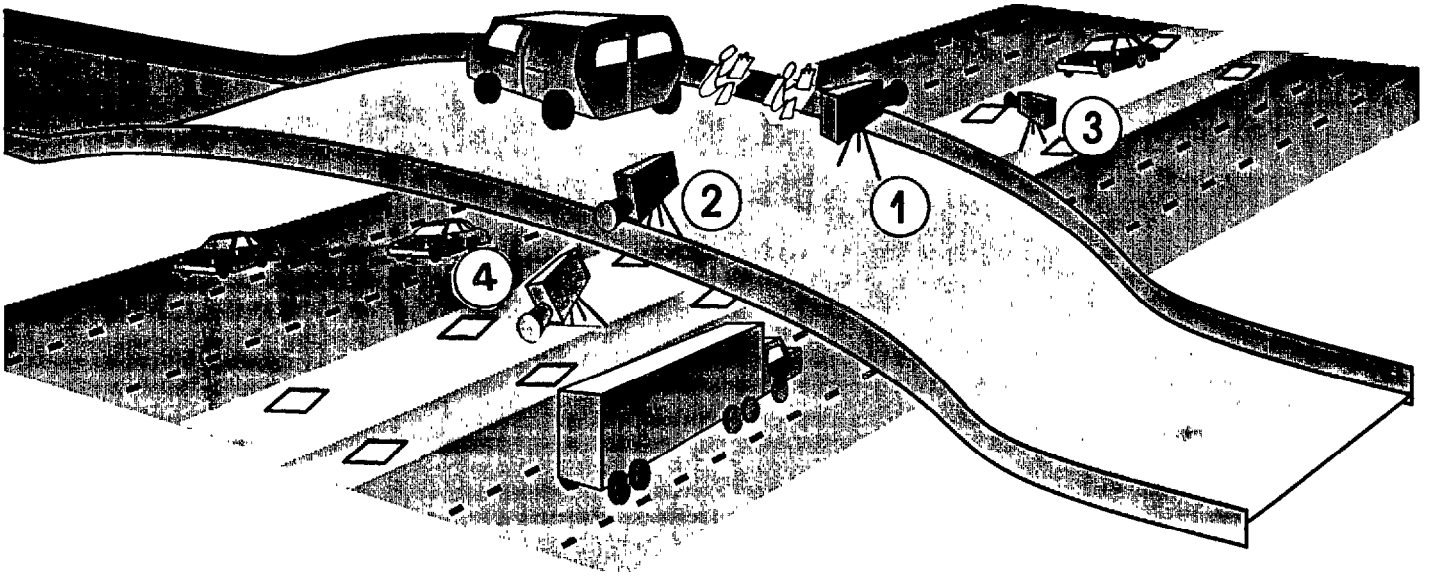
Cameras. Exhibit 3.9 shows the locations of the four cameras used in the demonstration. The cameras were installed and ready for use at 2:00 p.m. Between 2:00 p.m. and 4:00 p.m. three camera views were fed to the monitor: The oncoming scene recorded by Camera 1 of Exhibit 3.9, license plate data revealed by Camera 2, and an eye level view of passing

* Reasons for the lack of verifications varied. Some suspects bailed out of the lane when the downstream officers came into view. In other cases, the suspect description arrived too late, after the vehicle had already passed the enforcement area.

EXHIBIT 3.9

FINAL SET-UP

1. Oncoming View
2. License View from Bridge
3. Driver's Eye Level View
4. License View from Roadway



traffic provided by Camera 3. At four o'clock, Camera 4 was switched into the system to provide a freeway-level record of license plate information, replacing that of Camera 2. The views of Cameras 3 and 4 were synchronized to provide a simultaneous image of a car's interior and its license plate.

Enforcement. Three motor officers from the Santa Ana office were assigned to assist with the demonstrations. At two o'clock, the three officers took up positions at an enforcement area about 2,000 feet downstream from the overcrossing. Between two and three-thirty, the officers verified the occupancy levels of vehicles identified as potential violators by an ATD employee seated in the control van. At 3:30 one of the officers took over in the control van. Whereas the ATD employee was more adept at reviewing the tape to determine the license numbers of potential violators, the officer was better able to describe the suspect vehicles from their profiles ("Check out the white Camaro") and communicate his descriptions to his fellow officers.

Between 3:45 and 4:00, the officers left the enforcement area to cover an accident which occurred just downstream from the Warner Avenue overcrossing. There was no way to verify the occupancies of potential violators during this period. Aside from this single instance, however, the demonstration went smoothly.

3.4.2 Analysis of Results

Field Test Findings. A summary of the traffic observations made by the van occupants and field officers during the OR 55 demonstration appears on the following page:

TIME/ START/END/ VAN OBSERVER	SUSPECTED VIOLATORS OBSERVED	VIOLATOR DESCRIPTIONS ACKNOWLEDGED	VERIFICATION RESULTS			ADDITIONAL VIOLATORS SPOTTED BY FWY. OFFICERS	TOTAL VIOLATORS
			VIOLATOR VERIFIED	SUSPECT NOT A VIOLATOR	UNABLE TO OBSERVE SUSPECT		
2:15-2:30/C	6	5	3	2	1	0	3
2:30-2:45/C	8	5	3	2	3	1	4
2:45-3:00/C	7	6	3	3	1	0	3
3:00-3:15/C	4	4	2	2	0	2	4
3:15-3:30/C	2	2	1	1	0	1	2
3:30-3:45/C Officers Called Away at 3:45	3	3	0	3	0	0	0
4:00-4:15/O	3	3	1	2	0	1	2
4:15-4:30/O	2	2	0	2	0	4	4
4:30-4:45/O	9	9	4	5	0	1	5
4:45-5:00/O	9	8	2	6	1	2	4
	53	47	19	28	5	12	31

*C = Civilian Observer in Van
0 = Police Officer in Van

During the demonstration, field officers verified the occupancy of forty-seven vehicles identified as suspects by the van occupants. Of these forty-seven vehicles, nineteen (40.4%) turned out to be violators, while twenty-eight (59.6%) had the required number of occupants. These field results should not necessarily be used to gauge the accuracy of the video monitoring system, since the van occupants were under pressure to call out the identity of suspect vehicles before they passed the field officers 2,000 feet downstream. As a result, they sometimes identified suspects from the first view seen (the view provided by the single, head-on camera) without checking other views.

In this regard, the performance of the two observers was remarkably different. The monitoring observer in the van from 2:15 to 3:30 was a civilian employee of ATD familiar with the playback system and its controls. He was much more likely to check the view from the eye-level camera before alerting the field officers to the presence of a possible violator. On the other hand, the motor officer who took over at 3:30 was more likely to single out a potential violator on the strength of a single view from the head-on cameras. The relative accuracy of the two observers reflects their difference in approach: Of the twenty-two suspects identified by the civilian

observer, twelve (54.5%) actually turned out to be violators. In the case of the second observer, only seven of twenty-five suspects (28%) were found to be violators.

The on-line performance of both observers could undoubtedly have been improved if the enforcement area used as an observation post by the field officers had been further downstream. Both van operators were rushed to identify potential violators before they had passed the observation post.*

Data Reduction: Accuracy. In order to check the ability of reviewers to identify violators using the videotape alone, five observers reviewed different segments of the videotape and identify occupancy violators. Each observer was instructed in the use of the monitor and asked to identify those vehicles which they felt should receive citations for occupancy violations based solely on the videotape evidence.

The results of the review are summarized below:

Observer Number	Time Period	Violator Suspects Identified	Vehicles Checked In Field	Violator Verified	Suspect Not a Violator	False Alarm Rate
1	2:18-3:45	15	4	3	1	25%
	4:05-4:30	2	1	1	0	0%
2	2:18-3:45	89	19	9	10	52.6%
3	2:48-3:20	22	5	2	3	60%
	4:30-5:00	27	9	4	5	55.6%
4	2:45-3:00	18	5	2	3	60%
5	3:00-3:20	3	0	0	0	0%
TOTAL		176	43	21	22	51.2%

* The selection of monitor views may also have contributed to the tendency of the van operators to rely on a single image in identifying violators. During the first enforcement test on LA 91, the second image presented in the van was an oblique shot of the passenger seats taken from the overcrossing. This image followed the initial oncoming shot closely in time and the van officers tended to wait for it before judging a vehicle occupancy. The eye-level view of suspects did not appear on the screen until roughly seven seconds after the first view of the vehicle had disappeared, and the van observers appeared to be less likely to wait for this delayed view.

Forty-three of the 176 suspect vehicles identified by the videotape reviewers had been checked by field officers at the time the videotape was made. When these vehicles were compared with the officer reports, 22, or 51.2% were found to have the required number of occupants. Thus the false alarm rate for the eye-level camera was actually greater than that experienced with the bridge-level camera. Although the sample sizes were not large enough to be statistically significant, the high error rate suggests conclusively that videotape cannot currently be used as the sole means of identifying violators for enforcement purposes.

Data Reduction: Occupancy Counts. To obtain further insights into the relative accuracy of videotaped occupancy counts, three observers were asked to monitor videotapes of three different fifteen-minute periods of HOV lane activity, and record the number of occupants of each vehicle passing by the camera during each period. The occupancy counts recorded by each of the three videotape viewers are tabulated along with counts made by roadside observers in Exhibit 3.10.

The tabulations of Exhibit 3.10 show that the occupancy counts recorded by the three videotape viewers not only differ from those recorded by the roadside observer, but also from each other. Videotape observer #1 recorded occupancy rates that were consistently higher than those recorded by the roadside counter, while videotape observer # recorded consistently lower occupancy rates.* A three-way analysis of variance showed that the observers differed significantly among themselves in two key judgments: 1) identification of violators; and 2) identification of vehicles with three or more occupants.

Because of the marked differences in the results obtained from the three different videotape observers, it is difficult to draw any general conclusions regarding the relative accuracy of videotape vs. roadside observations in documenting vehicle occupancy. A careful check of the tape suggests that the roadside observers consistently understated the number of vehicles with

* The first observer displayed a tendency to understate violations and produce a relatively high number of 3+ vehicle sightings. She was reluctant to label a vehicle as a violator until she had carefully examined all three views of the vehicle, and searched each view thoroughly for evidence of a third passenger. Observer number 3 went through the videotape more quickly, requiring less evidence to label a suspected violator and spending less time searching for additional passengers. During the third fifteen-minute time period, where the sun's angle darkened the view from the eye-level camera, the tendencies of these two observers were magnified. Observer number 1 recorded only one violator during the period. She couldn't be sure there wasn't a second occupant out of her view. Observer number 3 found 26 possible violations during this same period, but only two vehicles with three or more occupants. Without the eye-level camera, he couldn't identify a third occupant with sufficient certainty.

EXHIBIT 3.10

OCCUPANCY COUNT COMPARISONS

Time Period	Buses	Motorcycles	Vehicle Occupancy					Computation	
	I/2 Full		1	2	3+	Don't Know	Total	Violation Rate	Occupancy Rate
2:45-3:15									
COUNTER	1	6	10	242	21	0	280	3.57%	2.10
Observer	2	7	7	203	50	20	289	2.60%	2.32
Observer 2	1	7	26	160	40	27	261	8.45%	2.17
Observer 3	1	7	21	188	10	39	266	9.25%	2.00
3:00-3:15									
COUNTER	0	11	11	234	10	0	266	4.14%	1.97
Observer 1	0	10	4	159	38	9	220	1.90%	2.20
Observer 2	0	9	18	159	27	20	233	7.84%	2.06
Observer 3	0	9	8	170	15	21	233	3.91%	1.93
4:15-4:30*									
COUNTER	1	9	7	218	23	0	258	2.71%	2.12
Observer 1	1	6	1	139	27	43	217	0.57%	2.27
Observer 2	1	5	16	160	22	22	226	11.11%	2.12
Observer 3	2	6	26	128	2	44	208	15.85%	1.97

*During this time period, the angle of the sun was such that the eye-level camera provided very few views inside passing vehicles.

three or more occupants, and therefore, presumably understated occupancy levels. This finding is not surprising, since it is easy to overlook some occupants and roadside observers must make instantaneous judgments without the benefit of the replay knob available to videotape viewers. Given the differences observed among videotape viewers, however, it is dangerous to extend this observation from the specific CALTRANS observers watching traffic on January 4 to the more general class of roadside observers. It is possible that another set of roadside observers might have overstated the number of vehicles with three or more occupants.* If there is one lesson to be learned from these comparisons, it is that different observers can produce widely different estimates of the occupancy levels of the same flow of vehicles. Consequently, when reviewing trends in traffic observations, sudden jumps in violation rates or occupancy levels should, be viewed with some skepticism if different observers were responsible for successive counts.

3.4.3 Preliminary Findings

Camera Positioning. Dropping the license plate camera to freeway level was viewed as a positive move at the time, since it synchronized the views from two of the cameras and took some of the guesswork out of the on-line review process. However, office personnel using the tape to identify violators preferred the license plate view generated by the overhead camera, since it often provided a view into the backseat of the vehicle as well.

Verification of Manual Counts. During the last two videotape demonstrations (December 19 on LA 91 and January 4 on OR 55), CALTRANS provided personnel who counted

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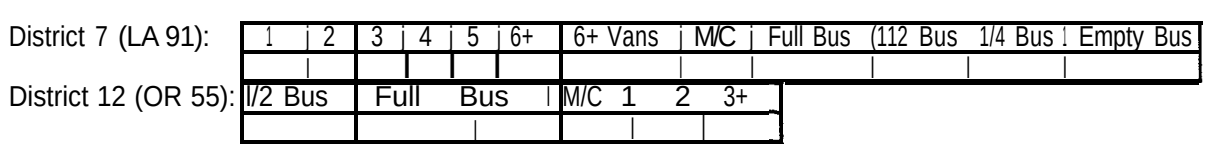
* This actually appears to have happened during the December 19 field test on LA 91. There CALTRANS counters from Division 7 used different forms from those used by the Division 12 counters observing OR 55. The headings on the two count sheets are reproduced below:



The availability of a counting slot for 6+ vans in the district 7 count sheets resulted in many entries being made in that category. A review of the videotape for that day suggested that many vans were being classified as 6+ occupants when it was impossible to see inside the van or when a van actually had far fewer than six occupants. In this case, therefore, the roadside observers undoubtedly overstated actual occupancy rates on LA 91. There is no way of knowing whether this tendency extends beyond the count crew assigned to the videotape field test. The current study was not designed to explore the accuracy of count crews in detail. However, the limited findings suggest that CALTRANS should standardize its count forms, train counters carefully, and check for differences among individual counters.

occupancy rates from their normal positions on the overcrossing. Two counters were available on both occasions. Preliminary results suggest that manual counts made from overcrossings may overstate the number of HOV lane violators.

The table below compares manual counts with the observations of roadside officers tallying violators downstream from the overcrossing.

FREEWAY:	O R	L A
TIME PERIOD:	1415 to 1530	1600 to 1630
VIOLATIONS OBSERVED BY COUNTERS	38	32
SUSPECTED VIOLATIONS OBSERVED BY MONITOR VIEWER	27	24
■ Violations Verified	12	8
Legitimate Vehicles	10	8
■ Vehicle Not Sighted	5	8
ADDITIONAL VIOLATIONS SPOTTED BY FIELD OFFICERS	4	0
TOTAL VERIFIED VIOLATIONS	16	8

In both cases, the viewer in the control van registered fewer suspected violators than the observers on the bridge. This is not surprising, since the van viewer had the ability to rewind the tape and take a second look at a suspect vehicle. Sometimes violators drove by while this review was taking place. However, the downstream officers were instructed to report on all violators they saw passing them, whether or not the viewer in the control van had alerted them to check a particular vehicle.

Only 50% of the suspect vehicles actually checked by the officers stationed beside the LA 91 HOV lane turned out to be violators. In the case of OR 55, 54.5% of the suspects identified by the monitor operator were violators. As noted, these figures should not necessarily be used to gauge the accuracy of the video monitoring system, since the van occupants were under pressure to call out the identity of suspect vehicles before the vehicles passed the police officers

downstream. However, the results do indicate that manual counts probably overstate the actual violation rate, perhaps even doubling it.*

While theoretically interesting, this knowledge may have little practical impact. Even if suspects turn out not to be violators (usually because there is a child out of the view of the camera and the CALTRANS counters), the fact that they look like violators can affect the public perception of the HOV lane.

HOV lane critics have accused CALTRANS in the past of understating actual violation rates. These critics are not likely to believe that the rates have actually been overstated, particularly when many vehicles which are actually legal Carpools look like violators. In this regard, one of the positive aspects of the use of videotape in HOV lane surveillance is that it provides a permanent record of HOV lane activity. Critics who doubt reported violation rates can be provided with copies of the relevant tape as a rebuttal.

Unambiguous Violator Identification: Buffer Violations. Although many suspected occupancy violations identified on videotape turned out to be false alarms, one type of violator could be unambiguously identified one hundred percent of the time. This was the buffer violator who entered the HOV lane illegally by crossing the double yellow line at a place where lane changing was not allowed. Exhibit 3.11 shows an example of one such violator.

Buffer violators can be easily identified, even when fast-forwarding through the videotape. So long as the violators are entering the lane (rather than leaving it), moreover, the appearance of the driver and the license plate of the vehicle will be recorded by the video surveillance system.

Accuracy and ambiguity: Missing Children. Infants or children hidden from the camera's view were the most common causes of violator misidentification by videotape viewers. Exhibit 3.12 shows three views of a taxi cab videotaped in the OR 55 HOV lane on January 4. The

* In all, the freeway officers on LA 91 saw eight violators in the same span of time that the counters tallied thirty-two. On OR 55, the freeway officers saw sixteen violators while the counters tallied thirty-eight. Heisenberg's principle affects these findings to a certain extent, since some violators left the lane when they saw officers in the enforcement area. However, when the violators were first under the scrutiny of the van occupants and the CALTRANS counters, they were well out of range of the officers in the enforcement area. The fact that the field officers found that only half of the suspects identified by the van occupants were actually violators, coupled with the relative number of sightings reported by the van observers and bridge counters, suggests strongly that the counters on the bridge were no more accurate than the observers in the control van.

EXHIBIT 3.11

MONITOR VIEW OF BUFFER VIOLATOR

EXHIBIT 3.12

MONITOR VIEWS OF SUSPECTED VIOLATOR WITH UNDETECTED CHILD

(Yellow Cab #51)

ONCOMING VIEW

SIDE VIEW

LICENSE VIEW

observer in the control van, along with four subsequent videotape viewers, independently identified the taxi as an HOV lane violator. However, the motor officer observing traffic in the lane downstream from the taping point reported that there was a small child in the cab's back seat. Yet four different observers failed to identify the child in repeated viewings and reviewings of the videotape.

Accuracy and Ambiguity: Tinted Wlndows. Exhibit 3.13 shows three views from the eye level camera. In the first view, the rear seat contains a passenger, the second vehicle is a violator (verified by the roadside observer), and the third vehicle has tinted windows, making a judgment on the occupancy of the rear seat impossible. Such problems as tinted windows, sight-obscuring headrests, windshield posts, and ill-positioned vehicles generally caused the videotape viewers to list the occupancy as unknown or guess at the occupancy from a single front view. Most test viewers were reluctant to identify vehicles as potential violators when one or more of the supporting views was obviously obscured. While tinted windows can produce indeterminant or biased occupancy counts, therefore, they are not likely to trigger false violation alarms, so long as the videotape viewers are well trained.

Certain vision-obscuring problems could potentially bias occupancy counts. The vehicles most likely to have windows out of range of the eye-level camera were buses and vans, precisely those vehicles which are likely to carry a high number of occupants. If videotape viewers ignore these vehicles because they can't see into the rear windows, occupancy rates will be artificially low. As noted, moreover, ambiguous views can cause different viewers to react in different ways. Faced with a large number of obscure views from the eye-level camera, one viewer understated violation rates because she shouldn't be sure there wasn't a second occupant somewhere in the car. Another viewer understated the number of vehicles with three or more occupants because he couldn't be sure the back seat was occupied.

EXHIBIT 3.13

VIEWS FROM EYE-LEVEL CAMERA SHOWING

1 – **Rear Seat Occupant**

2 – Empty Rear Seat

3 – TInted Windows